**Prevalence of Adenovirus Gastroenteritis Among Children Under Five Attending Faith Mediplex Hospital, Benin City, Edo State, Nigeria.**

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**ABSTRACT**

Adenoviruses are non-enveloped deoxyribonucleic acid (DNA) viruses that cause various illnesses, including gastroenteritis in children. Enteric adenovirus types 40 and 41 are notable causes of acute diarrhoea in children under five years, often leading to dehydration and increased morbidity. This study examined the prevalence, associated risk factors, and clinical characteristics of adenovirus infection among diarrheic under-five children at Faith Mediplex Hospital, Benin City. 150 stool samples were tested using immunochromatographic assays (Aria, USA), with supporting demographic and clinical data collected via piloted structured questionnaires. The overall prevalence was 5.3%, highest among infants under a year of age (20.0%), and absent in the 3–4-year age group. There was no statistically significant association between the prevalence of adenovirus infection (p = 0.863). While not statistically significant, infection was more frequently observed among children whose fathers had no formal education (22.2%) and mothers with tertiary education (10.7%), suggesting that education alone may not influence infection risk but some other factors. Clinically, blood in stool was the only symptom significantly associated with infection (22.6%, p = 0.001), pointing to potential mucosal damage. Other symptoms, such as fever and vomiting, showed no statistically significant link (p = 0.863). Moreover, overcrowding was identified as a critical environmental risk factor. Children living in overcrowded households showed a notably higher prevalence of adenovirus infection (13.0%) compared to those from less crowded homes (1.0%), with the difference being statistically significant (p = 0.017). This highlights the role of environmental hygiene and close person-to-person contact in facilitating viral transmission and possible infection. Adenovirus is a relevant cause of diarrhoea in young children, particularly in Edo State. Age, overcrowding, and blood in stool were found to be key indicators of infection. The findings from this study highlight the importance of promoting better personal hygiene, increased public awareness, and implementing sensitization programs to support timely diagnosis to help mitigate the impact of adenovirus gastroenteritis among children in Edo State and by implication Nigeria at large.

**Introduction**

Adenoviruses, first isolated in 1953, are non-enveloped DNA viruses that can cause various human infections (Bastug *et al.,* 2021). Adenoviruses belonging to the Mastadenovirus genus in the family Adenoviridae cause various diseases and are prevalent worldwide (De Francesco *et al.,* 2022; Amberg *et al.,* 2020). Other members of Adenoviruses include: Aviadenovirus (Infects Birds), Atadenovirus (Infects Reptiles, Birds, and Some Mammals), Siadenovirus (Infects Birds and Amphibians) (Kosoltanapiwat *et al.,* 2022). Adenovirus has become a valuable tool in medical research and therapeutic applications because Adenovirus vectors, created by modifying wild-type viruses, are used in gene therapy, cancer treatment, and vaccine development (Davison *et al.,* 2024). These vectors can be engineered to be replication-defective and carry therapeutic genes to specific tissues (Trivedi *et al.,* 2023). Researchers have introduced several modifications to improve vector efficiency, including fiber switching and capsid alterations (Benko *et al.,* 2022). Adenovirus vectors have played crucial roles in advancing cancer therapy, gene therapy, and vaccine development, particularly evident in recent COVID-19

vaccine successes (Trivedi *et al.,* 2023). Despite challenges faced when collecting those samples from infected individuals, ongoing research continues to optimize adenovirus vectors, promising new frontiers in cell and gene therapies (Trivedi *et al.,* 2023).

Gastroenteritis is the inflammation of the stomach and intestines, typically caused by viral, bacterial, or parasitic infections (De Francesco *et al.,* 2021). Gastroenteritis associated with adenovirus is a significant health concern, particularly in children under 5 years old (De Francesco *et al.,* 2021). While adenovirus types 40 and 41 are commonly linked to acute gastroenteritis, other non-enteric types may also play a role (De Francesco *et al.,* 2021). Adenovirus infections can be especially severe in immunocompromised patients, such as those undergoing hematopoietic stem cell transplantation and those with Human Immunovirus (HIV) (Davison *et al.,* 2022). Symptoms typically include vomiting and abdominal pain. (De Francesco *et al.,* 2022). Accurate diagnosis of adenovirus gastroenteritis may require a broad-range PCR methods to detect all adenovirus types as current techniques may have limitations because of co-infections with other enteric viruses such as rotavirus, norovirus, or astrovirus. (De francesco *et al.,* 2021).

Adenoviruses (AdVs) are globally distributed DNA viruses that can cause mild to severe infections in humans and animals (Kosoltanapiwat *et al.,* 2022). They can be fatal in immunocompromised individuals with untreated severe cases having mortality rates exceeding 50% (Hasan *et al.,* 2021). Economically, Adenoviruses impact both human health and agriculture, causing significant outbreaks in commercial poultry farming (Ruzlan *et al.,* 2021). Along with other respiratory viruses, Adenoviruses contribute to substantial morbidity, mortality, and economic losses worldwide (Ruzlan *et al.,* 2021)

Adenovirus is a significant cause of diarrhoea among children under five in Nigeria, with prevalence rates ranging from 8.7% to 29% (Nantege *et al.,* 2022). The incidence of adenovirus 40/41 diarrhoea peaks in children aged 7-15 months, with a substantial burden also observed in infants 0-6 months old (Guga *et al.,* 2022). Risk factors associated with diarrheal diseases include age, nutritional status, and water sources (Guga *et al.,* 2022). Exclusive breastfeeding strongly protects against adenovirus 40/41 diarrhoea because breast milk, especially colostrum, is rich in secretory immunoglobulin A (IgA), providing mucosal

immunity (Guga *et al.,* 2022). The seasonality of adenovirus infections varies between locations, with some studies reporting higher incidence during the dry season (Benko *et al.,* 2023).

## METHODOLOGY

A total of 150 stool samples from Faith Mediplex Hospital, Benin City, (selected for this study), were collected from October 2024 to December 2024. Stool samples were carefully collected in clean, sterile containers that were clearly labeled with each child's Mediplex identification number (ID) and the date inscribed. The collection was done by caregivers or hospital staff, who were given proper direction/instructions on how to collect the samples correctly. All the stool samples were then transported under a cold chain to the Medical Microbiology Laboratory at Igbinedion University Teaching Hospital, Okada, Edo State. Upon receipt of the stool samples at the Microbiology Laboratory, they were allowed to thaw at room temperature before serological screening using immunochromatographic techniques.

## RESULTS

Table 1 shows the sociodemographic characteristics of the infant's participants in the study. The majority of participants (55.3%) were aged 1-2 years, followed by 28.0% aged 3-4 years, and 16.7% aged less than a year of age. The mean age of infant's participants was 2.11±1.12 years. The sample was predominantly female (65.3%), and males 34.7%. Regarding the mothers' educational status, 6.0% had no formal education (the least group), this was closely followed by those with primary education (7.3%), the largest group had secondary education (68.0%) and others with tertiary education (18.7%). Similarly, for fathers' educational status included those with no formal education (6.0%) (least group), primary education (10.7%), most had secondary education (54.7%) (highest group), followed by tertiary education (28.7%). The least category of family with low income was 9.3% followed by those with high income 14.0% and majority of families were in the middle-income category (76.7%). In terms of the number of siblings, 50.7% of participants had 1-2 siblings, 26.0% had 3-4 siblings, and 23.3% had more than 4 siblings. Regarding residence, 56.7% of participants lived in rented accommodations, 27.3% in owned houses, and 16.0% in ancestral houses. The prevalence of

adenovirus infection was found to be 5.3% (8/150) as shown in figure 1.

**Table 1 Sociodemographic Characteristics of Participants**

| Variable | Number (n=150) | Percentage (%) |
|---|---|---|
| **Age** | | |
| <1 year | 25 | 16.7 |
| 1-2 years | 83 | 55.3 |
| 3-4 years | 42 | 28.0 |
| | | |
| **Sex** | | |
| Male | 52 | 34.7 |
| Female | 98 | 65.3 |
| | | |
| **Mothers' educational status** | | |
| No formal Education | 9 | 6.0 |
| Primary | 11 | 7.3 |
| Secondary | 102 | 68.0 |
| Tertiary | 28 | 18.7 |
| | | |
| **Fathers' educational status** | | |
| No formal Education | 9 | 6.0 |
| Primary | 16 | 10.7 |
| Secondary | 82 | 54.7 |
| Tertiary | 43 | 28.7 |
| | | |
| **Family's Income** | | |
| Low | 14 | 9.3 |
| Middle | 115 | 76.7 |
| High | 21 | 14.0 |
| | | |
| **Number of Siblings** | | |
| 1-2 | 76 | 50.7 |
| 3-4 | 39 | 26.0 |
| >4 | 35 | 23.3 |
| | | |
| **Mode of Residence** | | |
| Rented | 85 | 56.7 |
| Owned | 41 | 27.3 |
| Ancestral House | 24 | 16.0 |

Mean age=2.11±1.12 years.

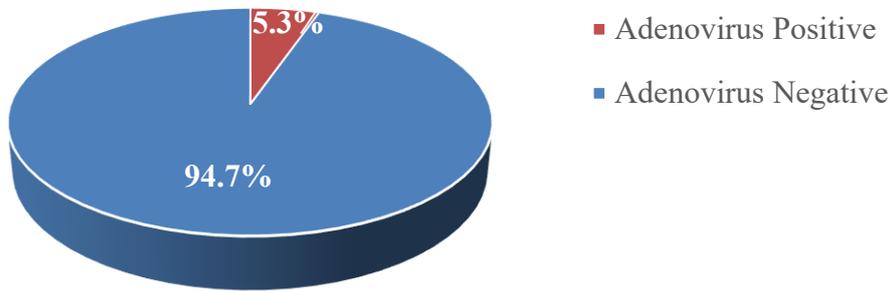- Adenovirus Positive
- Adenovirus Negative

**Figure 1 Prevalence of Adenovirus infection among diarrheic under five children attending Faith Mediplex Hospital.**
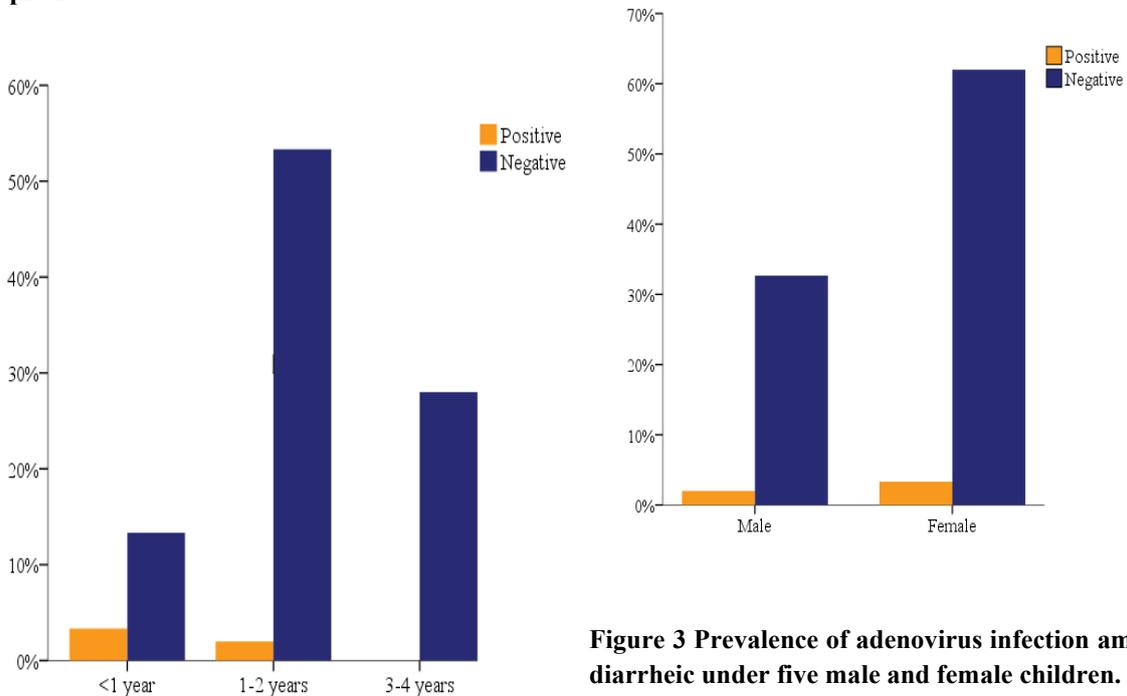


**Figure 2 Prevalence of adenovirus infection among different age groups.**



**Figure 3 Prevalence of adenovirus infection among diarrheic under five male and female children.**

**Sociodemographic Parameters and Prevalence of Adenovirus Infection**

The relationship between sociodemographic parameters and the prevalence of adenovirus infection was examined among 150 participants. Age was significantly associated with adenovirus infection (p = 0.001). Participants under a year of age had the highest prevalence of infection (20.0%), while those aged 1-2 years had a lower prevalence (3.6%), and no infections were observed in participants aged 3-4 years. Sex did not show a significant relationship with adenovirus infection (p = 0.863). Males had a slightly higher infection rate (5.8%) compared to females (5.1%), but this difference was not statistically significant (OR =

1.139, 95% CI: 0.261-4.966). Mothers' educational status was not significantly associated with adenovirus infection (p = 0.420). However, infection rates varied across educational levels, with those having tertiary education showing a higher infection rate (10.7%) compared to secondary (3.9%), primary (9.1%), and no formal education (0%). Fathers' educational status also did not show a significant relationship with adenovirus infection (p = 0.132). Participants whose fathers had no formal education had the highest infection rate (22.2%), while those with secondary education had the lowest rate (3.7%).

Family income was not significantly associated with adenovirus infection (p = 0.293). Participants from low-income families had a higher infection rate (14.3%) compared to those from middle (4.3%) and high-income families (4.8%). The number of siblings did not significantly impact the prevalence of adenovirus infection (p = 0.718). Participants with 1-2 siblings had an infection rate of 6.6%, compared to 5.1% for those with 3-4 siblings and 2.9% for those with more than 4 siblings. Lastly, the mode of residence was not significantly associated with adenovirus infection (p = 0.775). Infection rates were similar across different living situations, with participants living in rented accommodations showing an infection rate of 4.7%, those in owned houses 4.9%, and those in family houses 8.3% (Table 2).

**Table 2 : Relationship Between Sociodemographic Parameters and Prevalence of Adenovirus Infection**

| Variable | No. Examined (%) | No. Infected (%) | OR | 95%CI | p value |
|---|---|---|---|---|---|
| **Age** | | | | | |
| <1 year | 25 (16.7) | 5 (20.0) | | | 0.001 |
| 1-2 years | 83 (55.3) | 3 (3.6) | | | |
| 3-4 years | 42 (28.0) | 0 (0) | | | |
| **Sex** | | | | | |
| Male | 52 (34.7) | 3 (5.8) | 1.139 | 0.261-4.966 | 0.863 |
| Female | 98 (65.3) | 5 (5.1) | | | |
| **Mothers' educational status** | | | | | |
| None | 9 (6.0) | 0 (0) | | | 0.420 |
| Primary | 11 (7.3) | 1 (9.1) | | | |
| Secondary | 102 (68.0) | 4 (3.9) | | | |
| Tertiary | 28 (18.7) | 3 (10.7) | | | |
| **Fathers' educational status** | | | | | |
| None | 9 (6.0) | 2 (22.2) | | | 0.132 |
| Primary | 16 (10.7) | 1 (6.3) | | | |
| Secondary | 82 (54.7) | 3 (3.7) | | | |
| Tertiary | 43 (28.7) | 2 (4.7) | | | |
| **Family's Income** | | | | | |
| Low | 14 (9.3) | 2 (14.3) | | | 0.293 |
| Middle | 115 (76.7) | 5 (4.3) | | | |
| High | 21 (14.0) | 1 (4.8) | | | |
| **Number of Siblings** | | | | | |
| 1-2 | 76 (50.7) | 5 (6.6) | | | 0.718 |
| 3-4 | 39 (26.0) | 2 (5.1) | | | |
| >4 | 35 (23.3) | 1 (2.9) | | | |
| **Mode of Residence** | | | | | |
| Rented | 85 (56.7) | 4 (4.7) | | | 0.775 |
| Owned | 41 (27.3) | 2 (4.9) | | | |
| Ancestral House | 24 (16.0) | 2 (8.3) | | | |

P<0.05 represents significance

**Prevalence of Adenovirus in Relation to Risk Associated Factors**

The analysis of risk factors associated with adenovirus infection revealed significant associations with living conditions and toy-sharing habits. Children living in overcrowded conditions had a significantly higher risk of adenovirus infection (20.7%) compared to those in non-overcrowded conditions (1.7%), with an odds ratio (OR) of 15.52 (95% CI: 2.947-81.449, $p = 0.001$). Similarly, toy-sharing was significantly associated with an increased risk of infection, with children who shared toys showing a higher infection rate (16.7%) compared to those who did not (1.8%), with an OR of 11.20 (95% CI: 2.150-58.33, $p = 0.001$). Access to clean drinking water did not show a significant association with adenovirus infection ($p = 0.160$). However, children without access to clean drinking water had a higher infection rate (10.7%) compared to those with access (4.1%), with an OR of 0.356 (95% CI: 0.080-1.588). Proper sanitation practices were also not significantly associated with adenovirus infection ($p = 0.630$), with similar infection rates observed between children in environments with proper sanitation (5.1%) and those without (8.3%), with an OR of 0.588 (95% CI: 0.066-5.219). Regular handwashing showed no significant association with adenovirus infection, with similar infection rates between those who regularly washed their hands (5.4%) and those who did not (5.3%), and an OR of 1.023 (95% CI: 0.235-4.452, $p = 0.976$) (Table 3).

**Table 3: Prevalence of Adenovirus in Relation to Risk Factors.**

| Variable | No. Examined (%) | No. Infected (%) | OR | 95%CI | p value |
|---|---|---|---|---|---|
| **Living Conditions** | | | | | |
| Overcrowded | 29 (19.3) | 6 (20.7) | 15.52 | 2.947-81.449 | 0.001 |
| Not Overcrowded | 121 (80.7) | 2 (1.7) | | | |
| **Access to Clean Drinking Water** | | | | | |
| Yes | 122 (81.3) | 5 (4.1) | 0.356 | 0.080-1.588 | 0.160 |
| No | 28 (18.7) | 3 (10.7) | | | |
| **Proper Sanitation** | | | | | |
| Yes | 138 (92.0) | 7 (5.1) | 0.588 | 0.066-5.219 | 0.630 |
| No | 12 (8.0) | 1 (8.3) | | | |
| **Regular Handwashing** | | | | | |
| Yes | 93 (62.0) | 5 (5.4) | 1.023 | 0.235-4.452 | 0.976 |
| No | 57 (38.0) | 3 (5.3) | | | |
| **Sharing Toys** | | | | | |
| Yes | 36 (24.0) | 6 (16.7) | 11.20 | 2,150-58.33 | 0.001 |
| No | 114 (76.0) | 2 (1.8) | | | |

P<0.05 represents significance

**Prevalence of Adenovirus Infection in Relation to Symptoms of Diarrhoea**

The analysis of some symptoms associated with diarrhoea revealed significant associations with the prevalence of adenovirus infection. Children with blood in their stool had a significantly higher prevalence of adenovirus infection (22.6%) compared to those without blood in stool (0.8%), with an odds ratio (OR) of 34.417 (95% CI: 4.046-292.74, $p = 0.001$). Fever, vomiting, and abdominal pain did not show significant associations with adenovirus infection. Specifically, children with fever had a slightly higher infection rate (6.5%) compared to those without fever (4.8%) with an OR of 1.381 (95% CI: 0.316-6.041, $p = 0.667$). Similarly, vomiting (6.7% vs. 5.0%, OR = 1.357, 95% CI: 0.260-7.087, $p = 0.716$) and abdominal pain (6.3% vs. 4.7%, OR = 1.367, 95% CI: 0.329-5.684, $p = 0.666$) were not significantly associated with adenovirus infection (Table 4).

**Table 4: Prevalence of Adenovirus in Relation to Symptoms of Diarrhoea.**

| Variable | No. Examined (%) | No. Infected (%) | OR | 95%CI | p value |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Fever** | | | | | |
| Yes | 46 (30.7) | 3 (6.5) | 1.381 | 0.316-6.041 | 0.667 |
| No | 104 (69.3) | 5 (4.8) | | | |
| **Vomiting** | | | | | |
| Yes | 30 (20.0) | 2 (6.7) | 1.357 | 0.260-7.087 | 0.716 |
| No | 120 (80.0) | 6 (5.0) | | | |
| **Abdominal Pain** | | | | | |
| Yes | 64 (42.7) | 4 (6.3) | 1.367 | 0.329-5.684 | 0.666 |
| No | 86 (57.3) | 4 (4.7) | | | |
| **Blood in Stool** | | | | | |
| Yes | 31 (20.7) | 7 (22.6) | 34.417 | 4.046-292.74 | 0.001 |
| No | 119 (79.3) | 1 (0.8) | | | |

P<0.05 represents significance

## DISCUSSION

This study examined the prevalence and risk factors for adenovirus infection in children under 5 years of age who had diarrhea and were receiving treatment at Faith Mediplex Hospital in Benin City, Edo State. In this study, it was observed that Children aged 1–2 years contributed the highest prevalence, accounting for 3.6%, while the lowest positive cases (0.0%) were seen in children between 3- 4 years of age. These findings align closely with existing research by Guga *et al.* (2022) who conducted a cross-sectional study in Northern Nigeria using polymerase chain reaction (PCR)- based diagnostics on 204 stool samples from diarrheic under-five years of age children and found that over 60% of adenovirus-positive cases occurred in children under 2 years, attributing this to immature immune systems development and early exposure to adenovirus contaminated objects. Similarly, Guga *et al*. (2022) examined a total of 150 children under five years of age with diarrhoea in Southwest Nigeria and reported that the majority of adenovirus infections occurred between 6 and 24 months of age, reinforcing that early infancy and toddlerhood are critical risk windows. The findings are further supported by De Francesco *et al.* (2021) and Trivedi *et al.* (2023), who reported that enteric adenoviruses, particularly types 40 and 41, affect children below the age of two, due to immature immune defenses, lack of prior exposure, and greater environmental contact through hand-to-mouth behaviors which is often displayed by infants.

Considering the prevalence of adenovirus gastroenteritis among genders in this study, 65.3% of children were females and 34.7% were males, showing a female-dominant participant pool. However, adenovirus infection rates were almost evenly distributed between sexes (males 5.8%, females 5.1%), and this difference was not statistically significant (*p* = 0.863). This observation aligns with findings from Nantege *et al.* (2022) and Ndoboli *et al.* (2023), who found no significant association between gender and adenovirus infection. Globally, (Ndungutse *et al.,* 2022) support the idea that adenovirus infections are not gender-specific, with both male and female children equally susceptible under similar exposure conditions. Random sample variability or behavioral characteristics like boys' propensity for exploratory or high-contact play behaviors, which increases their exposure to contaminated surfaces and objects, could be responsible for the small variation observed in this study. However, both genders were similarly exposed to transmission vectors, including sharing toys, food, and water in structured situations like homes and clinics where hygiene conditions are often uniform, which could explain the slight differences seen.

This study also assessed parental educational background. To determine the impact on the likelihood of adenovirus infection among diarrheic children under 5 years of age. The analysis revealed no statistically significant correlation between adenovirus infection and either parent's level of education (p=0.863). However, the highest infection rate (22.2%) was observed in children whose fathers had no formal education, while among mothers, the highest infection rate (10.7%) occurred in those with tertiary education. These findings, though not statistically significant (p=0.863), present a paradoxical trend, suggesting that educational attainment alone may not reliably predict infection risk, especially within the complex socioeconomic dynamics of urban Nigerian settings. Several other studies across Nigeria support this outcome. Offor *et al.* (2022), in a study on diarrhoeal

diseases in Southern Nigeria, reported that maternal education level did not significantly reduce infection rates among children under five years of age. The researchers emphasized that although education improves awareness, it does not always lead to improved health outcomes unless accompanied by appropriate behavioral practices, adequate infrastructure, and access to basic services like clean water and sanitation. Similarly, (Shieh *et al.,* 2022) found that socioeconomic conditions often overrode the benefits of education, especially when households face constraints such as overcrowding and inconsistent water supply.

Additionally, this study examined the clinical symptoms of adenovirus gastroenteritis, with a particular focus on markers that could assist in early clinical detection among children under five years of age. Of all the symptoms evaluated, blood in stool emerged as a statistically significant clinical indicator (p=0.001), with a prevalence of 22.6% among children presenting with this symptom, compared to 0.8% in those without it. This finding is especially important as adenovirus infections, specifically types 40 and 41, are traditionally associated with watery, non-bloody diarrhoea. However, the data from this study indicated that in certain cases, particularly among infants or immunocompromised children, adenovirus may present more aggressively, potentially causing haemorrhagic enteritis and mucosal injury. This observation is supported by Kajon *et al.* (2022), who noted that while the majority of adenovirus gastroenteritis cases are non-inflammatory, atypical presentations involving bloody diarrhoea have been reported, especially in severe cases of co-infection. Similarly, De Francesco *et al.* (2021) reported that adenoviral cytopathic effects can result in epithelial cell destruction, leading to mucosal ulceration and bleeding in the gastrointestinal tract. These complications are more likely to occur in children with high viral loads or underlying nutritional deficiencies. Furthermore, clinical insight was provided by Kajon *et al*. (2020), whose review of adenoviral pathogenesis emphasized that strong viral replication or co-infection with bacterial pathogens (e.g., *Shigella spp* or *Campylobacter spp*) can exacerbate mucosal inflammation, resulting in ulcerative lesions. These findings offer a plausible explanation for the association between adenovirus and blood in stool observed in this study, suggesting that these symptoms, although uncommon, should raise a high index of suspicion for viral gastroenteritis, especially when laboratory testing facilities are unavailable.

With due considerations, this study offers a critical perspective on the epidemiology of adenovirus infection in Edo State's children under five years of age. The results highlight the necessity of clinical knowledge for early detection and management of adenoviral infection, as well as focused initiatives targeting environmental cleanliness, hygiene education, and household overcrowding.

## CONCLUSION

This study has shown that adenovirus is a notable cause of diarrhoea among children under five years of age in Benin City, Edo State. The infection was most common in younger children and was associated with factors such as poor hygiene, and certain socio-demographic characteristics such as age, parental education level, and gender. Blood in stool was a significant clinical marker of infection in this study. These findings underscore the public health importance of adenoviral gastroenteritis and highlight the need for greater awareness, early detection, and preventive efforts to reduce its burden among vulnerable populations; infants.

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